

Segmentation of X-ray tomographic images contribution to weathering analysis of building limestones originating from historical buildings

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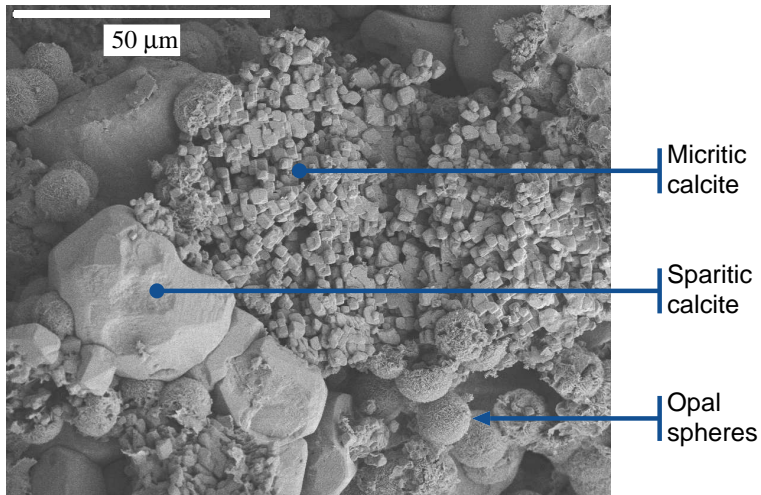
June 7, 2007

Cultural heritage in the Loire valley



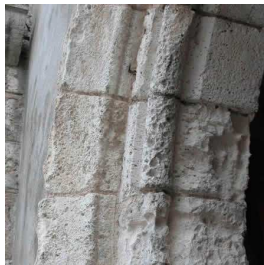
Château de Chambord

The tuffeau building stone



SEM image of a tuffeau sample, $\times 1000$.

Weathering of building stones

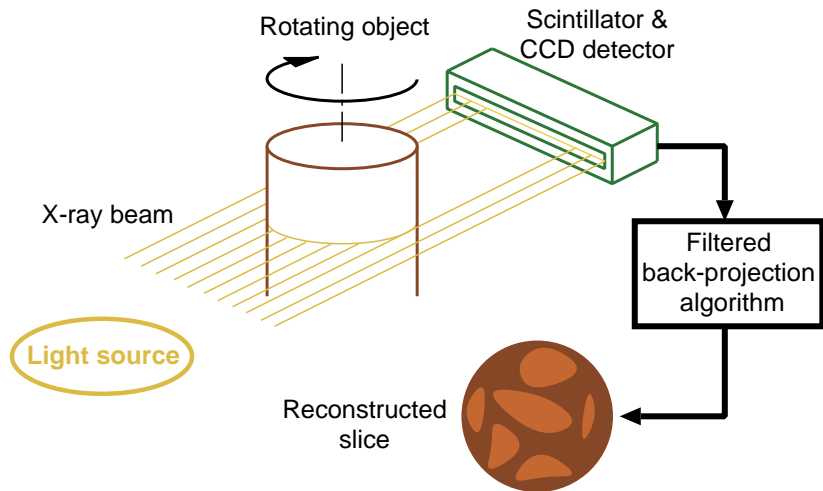


Examples of alterations
due to weathering

- ▶ granular disintegration,
- ▶ loss of crust,
- ▶ loss of scales, etc.

The idea: understanding the mechanisms of weathering via some physical model. Such a model requires a good description of the **microstructure** of the medium.

principle of X-ray tomography

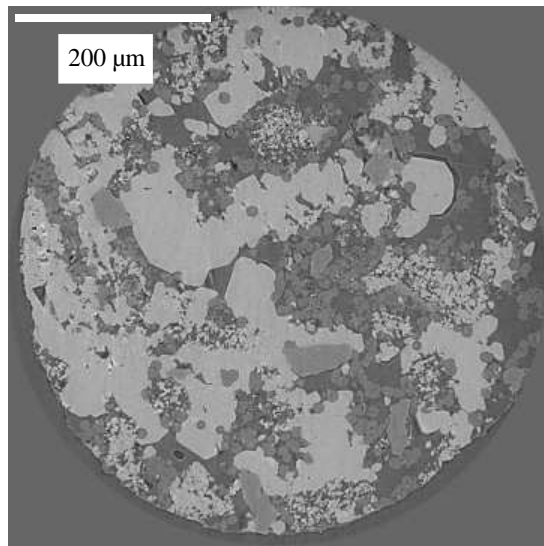


X-ray microtomography at the ESRF



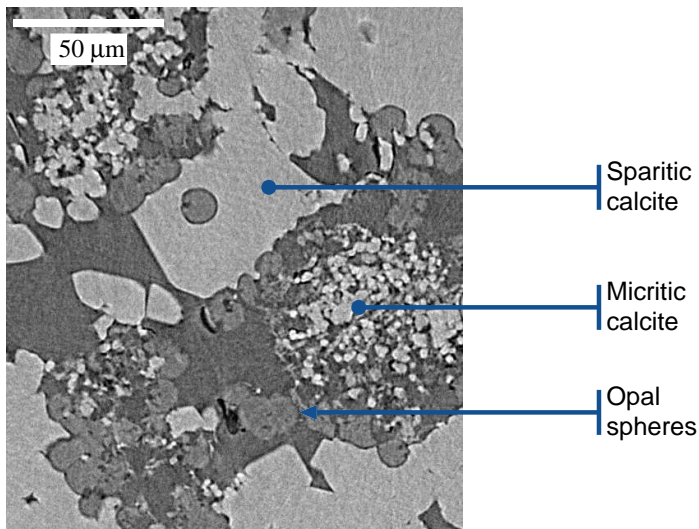
The European Synchrotron Radiation Facility, Grenoble.

Example of image obtained



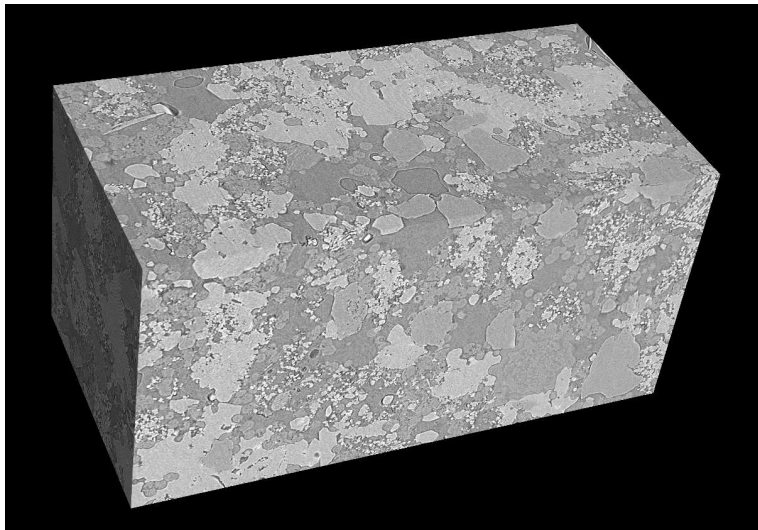
- ▶ One sample section over 2048,
- ▶ image is 2048 × 2048 pixels,
- ▶ pixel size is 0.27 μm.

Example of image obtained



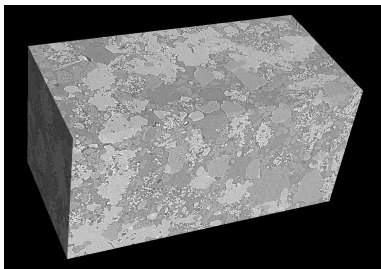
Zoom on the previous image (556 \times 640 voxels).

Example of image obtained



3D sample, image is $1024 \times 1024 \times 2048$ voxels ($0.27 \times 0.27 \times 0.55$ mm).

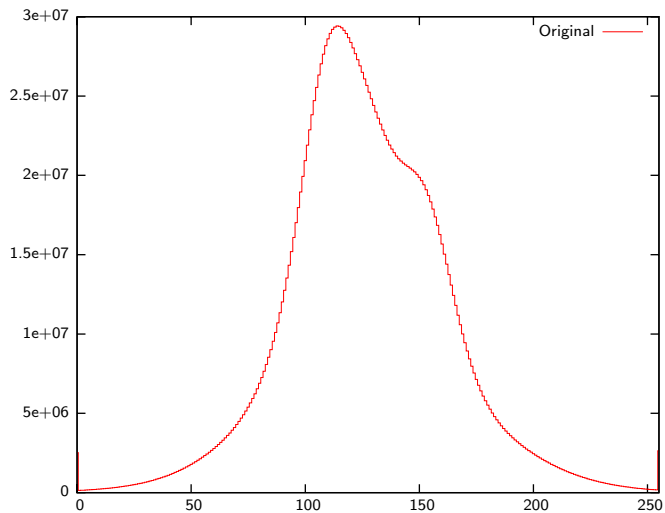
How to extract the microstructure?



Extracting the structure of the image requires to identify the phases (calcite, silica and void), i.e. to **segment** the image.

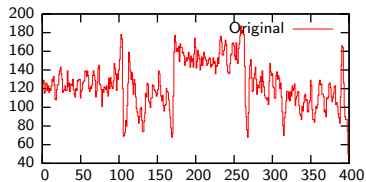
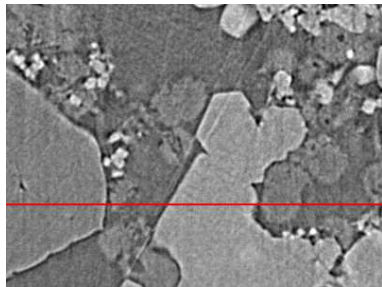
Each phase should be identified by its grey level in the image (wich is connected to the X-ray absorption coefficient of the phase).

How to extract the microstructure?



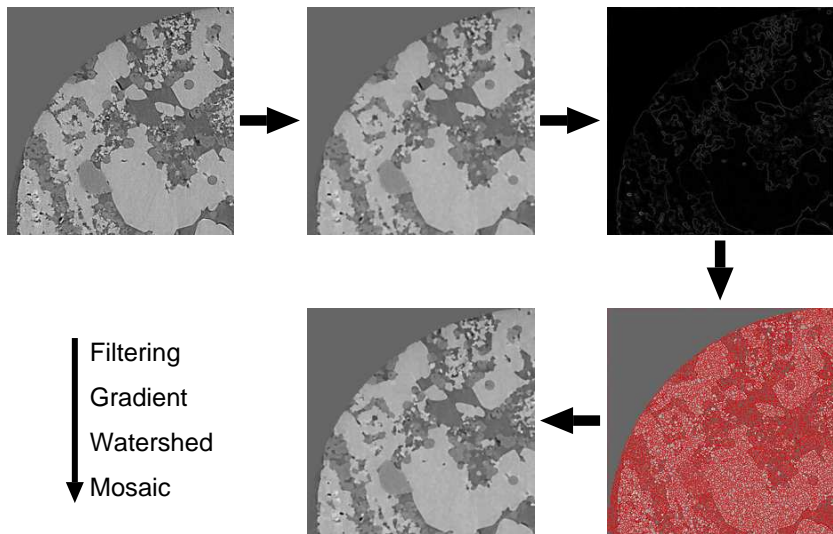
Histogram of the 3D image.

How to extract the microstructure?



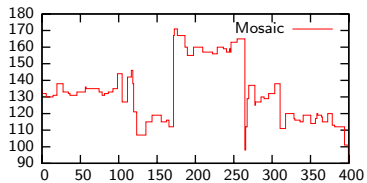
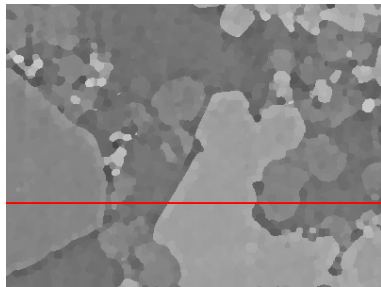
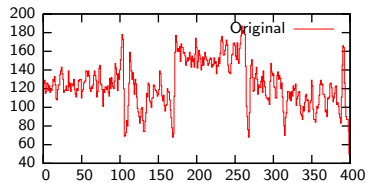
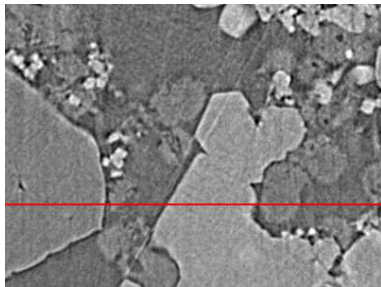
The images are noisy!
Impossible to segment as they are.

The method

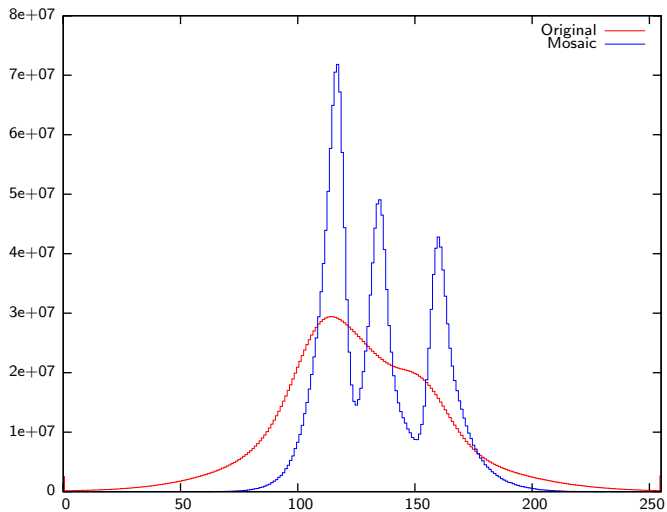


The image analysis method.

Results

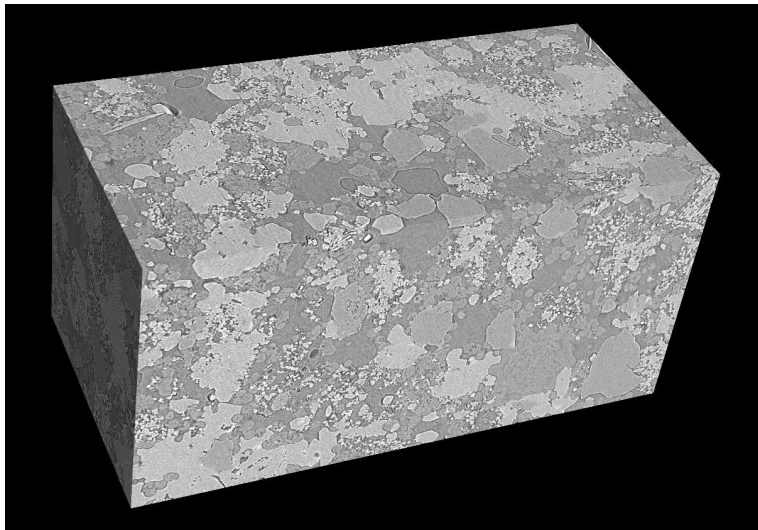


Results



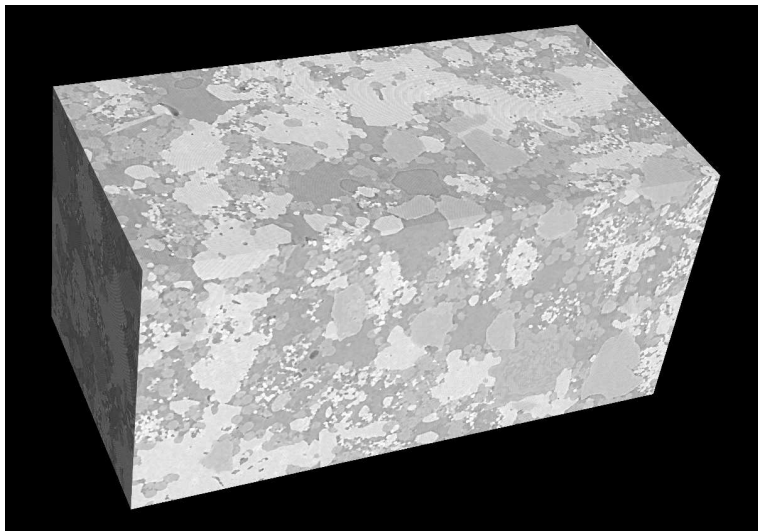
Histogram of the 3D original image & mosaic.

Results



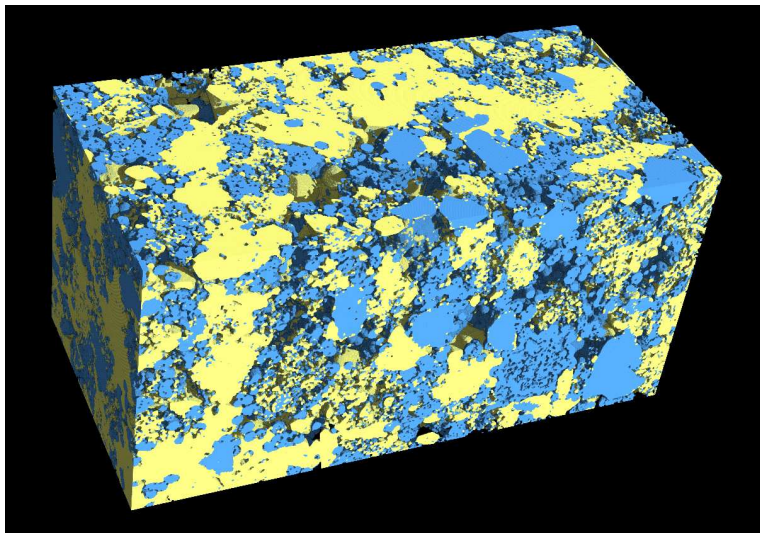
The 3D sample.

Results



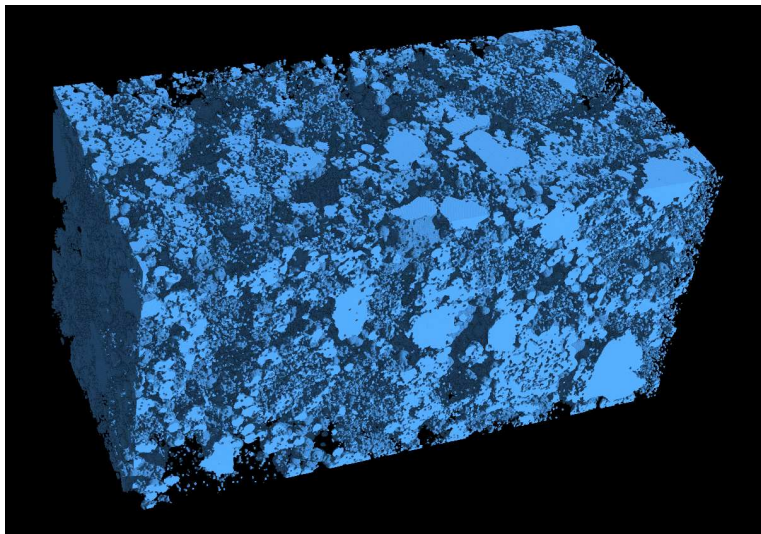
The mosaic.

Results



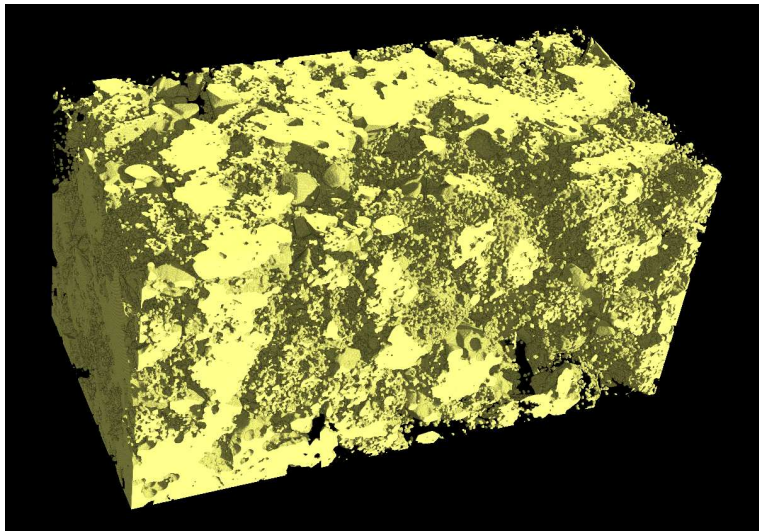
The segmented image (calcite is yellow, silica is blue).

Results



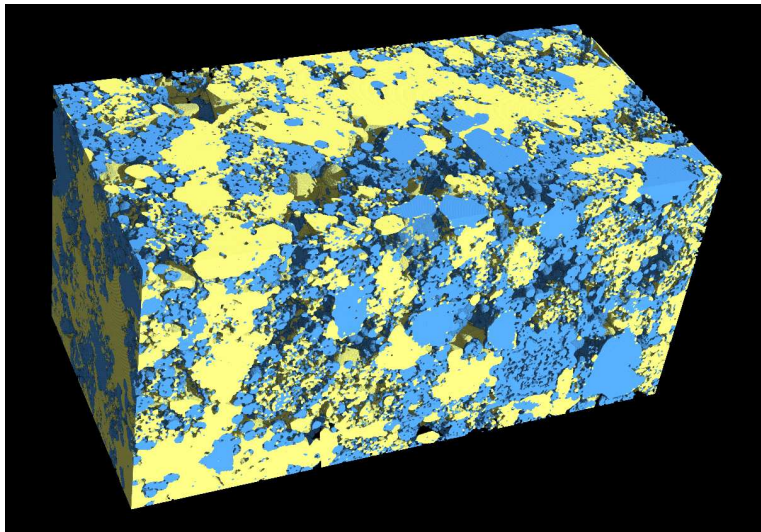
The silica phase.

Results



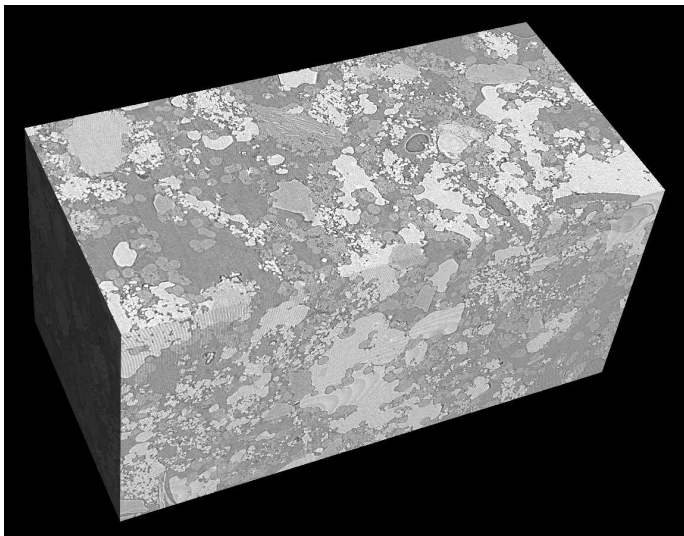
The calcite phase.

Results



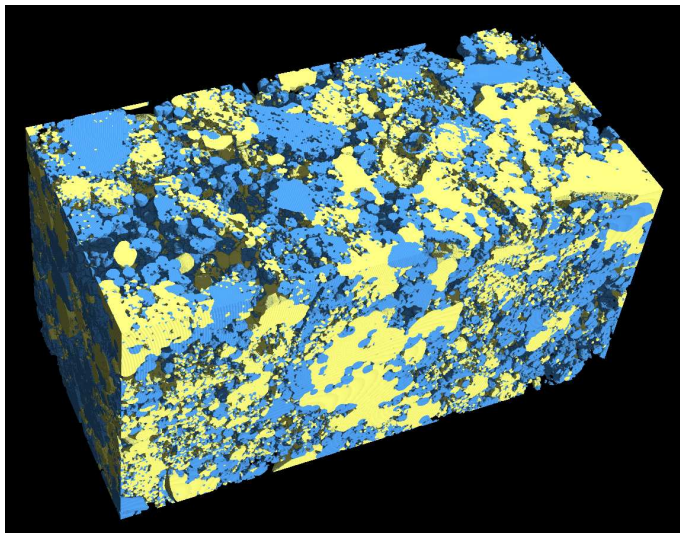
In this image, porosity is 34.2%, calcite is 38.3%, silica 27.5% (in vol.)

Results



Another sample.

Results



In this image, porosity is 35.5%, calcite is 37.9%, silica 26.6% (in vol.)